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FREE-SPINNING, LONGITUDINAL-TRIM, AND TUMBLING

TESTS OF $\frac{1}{17.8}$ - SCALE MODELS OF THE

CORNELIUS XFG-1 GLIDER

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NACA

WASHINGTON

NACA LANGLEY MEMORIAL AERONAUTICAL LABORATORY

MEMORANDUM REPORT

for the

Air Technical Service Command, Army Air Forces

MR No. L5K21

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SUMMARY

A series of tests has been performed in the Langley
free-spinning tunnels to determine the spin and recovery
characteristics, longitudinal-trimming characteristics at
extreme angles of attack, and tumbling tendencies of a
$\frac{1}{17.8}$-scale model of the Cornelius XFG-1 glider. The
tests were made at an equivalent altitude of 15,000 feet.

The effects of loading, mass distribution, and
center-of-gravity position upon the model characteristics
were determined. The inverted spin characteristics and
the spin-recovery parachute requirements were also
investigated.

The results of the tests showed that the model would
spin in a flat attitude with extreme oscillations. In
general, reversal of the rudder alone or extension of the
spoilers stopped the spinning rotation, but the model
remained in a stalled glide. Movement of the elevator
down pitched the model out of this glide. Longitudinal-
trim tests indicated that increasing the elevator-down
setting to 20° insured pitching the model from this
stalled glide, but the spin results indicated that care
must be exercised to avoid entering an inverted spin.
A 4.5-foot and a 7.5-foot (laid out flat diameter) silk
tail parachute effected satisfactory recoveries when
opened during spins of the glider for the minimum flying

weight and the fully loaded conditions, respectively.
The model would tumble unless the elevators were held
against the rotation.

INTRODUCTION

At the request of the Army Air Forces, Air Technical
Service Command, a series of tests has been performed in
the Langley free-spinning tunnels to determine the spin
characteristics, longitudinal-trim characteristics, and
tumbling tendencies of a $\frac{1}{17.8}$-scale model of the XFG-1
glider. The wings of the glider are swept forward and
are located near the rear of the fuselage and have
spoilers to aid in landing. The glider has a con-
ventional vertical tail surface but has no horizontal
tail surface, the elevator controls being on the wings
inboard of the ailerons.

Two loadings were tested, corresponding to the
glider in the minimum flying weight condition, and in
the fully loaded condition. The spin and recovery
characteristics for both loadings were determined with
the spoilers neutral or extended, with the landing gear
on and off, with forward and rearward positions of the
center of gravity, and with various moderate changes in
mass distribution. The inverted-spin characteristics
for both loading conditions were also determined, and
the effect of increasing the wing dihedral was deter-
mined for the minimum flying weight condition. Spin-
recovery tail parachute tests were made for both loading
conditions. The longitudinal-trimming tendencies of the
model mounted free to pitch were investigated, the
effects of spoilers, landing gear, and center-of-gravity
location being determined.

Tumbling tests were made for the model in the mini-
mum flying weight and fully loaded conditions, during
which the effects of center-of-gravity positions,
spoilers, and landing gear were determined.

SYMBOLS

S	wing area, square feet
b	wing span, feet
m	mass of glider, slugs
$\bar{c}$	mean aerodynamic chord, feet
$x/\bar{c}$	ratio of distance of center of gravity rearward of leading edge of mean aerodynamic chord to mean aerodynamic chord
$z/\bar{c}$	ratio of distance between center of gravity and fuselage centerline to mean aerodynamic chord (positive when center of gravity is below fuselage centerline)
I_X, I_Y, I_Z	moments of inertia about X, Y, and Z body axes, respectively, slug-feet^2
$\dfrac{I_X - I_Y}{mb^2}$	inertia yawing-moment parameter
$\dfrac{I_Y - I_Z}{mb^2}$	inertia rolling-moment parameter
$\dfrac{I_Z - I_X}{mb^2}$	inertia pitching-moment parameter
$\mu = \dfrac{m}{\rho Sb}$	airplane relative density
ρ	air density, slug per cubic foot
V	full-scale true rate of descent, feet per second
α	angle of attack, degrees

APPARATUS AND METHODS

Model

Two dimensionally identical $\frac{1}{17.8}$-scale models of
the XFG-1 glider were built and prepared for testing
by Langley. Two models were built in order to expedite
the tests in case of excessive damage to one of the
models and because a model built to be ballasted for
the light loading would be too weak structurally for the
heavy loading.

The dimensional characteristics of the full-scale
glider are given in table I. A three-view drawing of the
model with the landing gear on is presented in figure 1.
Photographs showing the model with the spoilers extended,
landing gear off and on, are shown in figure 2.

The models were ballasted with lead weights to
obtain dynamic similarity to the glider at an altitude
of 15,000 feet ($\rho = C.001496$). A remote-control mecha-
nism was installed in each model to actuate the controls
for the recoveries. The landing gear was independently
ballasted so that correct mass characteristics were
obtained for the model with landing gear cff and on.

Wind Tunnel and Testing Technique

The tests were performed in the Langley free-
spinning wind tunnels - the spin and tumbling tests in
the 20-foot tunnel, the longitudinal-trim tests in the
15-foot tunnel.

With few exceptions, the operation of the 20-foot
tunnel is similar to that of the 15-foot tunnel as
described in reference 1. The model launching technique
for spin tests has been changed from launching with a
spindle to launching by hand with spinning rotation.

Spin tests.- The spin data presented were determined
by the methods presented in reference 1 and have been
converted to corresponding full-scale values. Because
of the oscillatory and wandering motion of the models,
quantitative data could generally not be obtained; there-
fore, only a description of the model motion before,

and the flight path after, control reversal is presented,
together with the number of turns it took the model to
stop rotating after the control was reversed. The tests
were performed for the normal spinning control configu-
ration (elevator full up, ailerons neutral, and rudder
full with the spin) and for various other aileron-elevator
deflection combinations including neutral and maximum
deflections of the surfaces for the various conditions
tested.

For the spin-recovery parachute tests, the model
was launched into its spinning condition with the rudder
set full with the spin. Recovery was then attempted by
opening a tail parachute. The parachutes used were the
flat circular type made of silk and had a drag coef-
ficient of approximately 0.7 based on the surface area
of the canopy. The diameter was measured when the para-
chute was laid out flat. The towline was attached to
the tail cone of the model and the parachute was packed
in such a manner so as not to change the spinning con-
dition.

Longitudinal-trim tests.- For the longitudinal-trim
tests, the model was mounted on a special rig fixed in
the center of the tunnel. (See fig. 3.) The model was
restrained from any movement about the roll and yaw axes,
but was free to rotate about a pitch axis through an
angle of plus or minus 90°. Provision was made for
mounting the model at various center-of-gravity locations
through a range of from 9 to 19 percent of the mean aero-
dynamic chord. The model was mass-balanced about the
pitch axis for the particular center-of-gravity location
desired.

The model was rotated to zero angle of attack by
strings attached to the nose and tail. The airspeed in
the tunnel was then increased and the model was allowed
to assume an angle of trim. In order to determine if
there was more than one angle of trim for any condition,
the model was rotated by means of the strings, and the
trim angle was measured when the strings were released.
The trim angles were read by means of a protractor
mounted on a tunnel window which was approximately
parallel to the plane of symmetry of the model. These
tests were arbitrarily performed with an approximate
tunnel airspeed of 44 feet per second.

Brief force tests were also run in the free-flight tunnel to determine the neutral point of the model and to obtain data which could be compared with the results of similar balance tests performed at Wright Field.

·Tumbling tests.- In order to determine the tumbling tendencies of the model, the model was either released from a nose-up position to simulate a whip-stall or was given an initial pitching rotation about a lateral axis. In the tests in which initial rotation was given the model, because of the confined space of the tunnel, only enough pitching moment was applied by hand to insure that the model would make at least one complete turn before it struck the safety net for cases in which it would tumble, or that the model would make approximately one complete turn before it stopped rotating for cases in which it would not tumble. The number of turns the model took before it ceased to tumble or before it hit the safety net was observed, as well as the behavior of the model while it was tumbling and after it ceased to tumble.

Moving pictures were taken of both types of tumbling tests so that a study of the model motion could be made. Approximate vertical rates of descent of the model during the tumbling tests were determined from the film records of the tumbling maneuver and from the tunnel airspeed. The camera speed being known, the apparent vertical rate of descent was determined from the number of frames of film in which the model moved a certain vertical distance. This apparent vertical rate of descent was added to the tunnel airspeed, giving an approximate vertical rate of descent of the model during the tumbling maneuver. Three rudder-aileron control combinations were tested for elevator full up, neutral, and full down: rudder neutral, ailerons neutral; rudder fully deflected, ailerons neutral; rudder neutral, ailerons fully deflected.

PRECISION

Inasmuch as the motion of the model during spin tests was mostly very wandering and oscillatory, the only precise data obtained were the number of turns the model took to stop rotating after control reversal.

These turns are believed to be the true model values within the following limits:

$\pm\frac{1}{4}$ turn when obtained from film records

$\pm\frac{1}{2}$ turn when obtained from visual observation

These limits may have been exeeded somewhat for cases in which the model was extremely difficult to test. Only approximate values of rates of descent and rotation could be obtained.

The angles of trim of the model obtained from the longitudinal-trim tests are believed to be within $\pm2^{\circ}$ of their true values.

A comparison of model and airplane spin results (references 1 and 2) indicated that the spin-tunnel results were not always in complete agreement with the full-scale airplane results. In general, models spin at a somewhat smaller angle of attack, at a somewhat higher rate of descent, and with 5° to 10° more outward sideslip. The comparison made in reference 2 showed that 80 percent of the model recovery tests predicted satisfactorily the corresponding full-scale recoveries and that 10 percent overestimated and 10 percent underestimated the full-scale recoveries.

Because of limits of accuracy in ballasting the models and because of inadvertent damage to the models during the spin tests, the measured weight and mass distribution of the model varied from the true scaled-down values by the following limits:

Model ballasted for minimum flying weight condition
   (with pilot and landing gear)

Weight, percent . . . . 0 low, 3 high
Center of gravity . . . . 0.01$\bar{c}$ rearward to 0.05$\bar{c}$
                                             forward of normal
Moments of $\left\{ \begin{array}{l} I_X \\ I_Y \\ I_Z \end{array} \right.$

I_X . . . . 1 low, 22 high
I_Y . . . . 21 low, 1 low
I_Z . . . . 7 high, 15 high

inertia,
percent

Model ballasted for fully loaded condition (with pilot
    and landing gear)

Weight, percent . . . . 2 low, 1 low
Center of gravity . . . . 0.05c̄ rearward to 0.01c̄
                                              forward of normal
Moments of $\left\{\begin{array}{l} I_X. \text{. . . . . 5 high, 17 high} \\ I_Y. \text{. . . . . 9 low, 15 high} \\ I_Z. \text{. . . . . 8 high, 32 high} \end{array}\right.$

inertia,
percent

        The accuracy of measuring the weight and mass dis-
tribution of the model is believed to be within the
following limits:

Weight, percent . . . . ±1
Center-of-gravity location, percent c̄ . . . . ±1
Moments of inertia, percent . . . . ±5

The controls were set with an accuracy of ±1°.

                        TEST CONDITIONS

        Spin tests were made for the model conditions given
in table II. The mass characteristics and inertia
parameters for the possible loadings of the glider are
shown in table III. The values of the corresponding mass
characteristics and inertia parameters for the models as
tested are presented in table IV. In addition, the
inertia parameters for both the models and glider are
plotted on figure 4. The basic loadings tested were
the minimum flying weight with pilot and landing gear
and the fully loaded condition, with pilot and landing
gear. These loadings are herein referred to as the
minimum flying weight and the fully loaded conditions.

        The maximum control deflections used for spin and
tumbling tests were:

Rudder . . . . 25° right, 25° left
Elevator . . . . 30° up, 20° down
Ailerons . . . . 20° up, 15° down
Spoilers . . . . 90° up

At the start of the spin tests the maximum down-elevator travel was only 10°, but subsequent to the longitudinal-trim tests the elevator-down deflection was changed to 20°. The maximum down-elevator travel used for the tests is noted on each of the tables of results.

Variations in mass distribution were investigated in order to allow for the limits of accuracy of the computed glider and model values and also to allow for any rearrangement of loading which might lead to a spinning condition in which a longer period of time is required for recovery after control reversal.

For the investigation of the effect of wing dihedral on the spinning characteristics of the model, the wing dihedral was increased from 2° to 8°.

The conditions tested for the longitudinal-trim tests and tumbling tests are given in tables V and VI, respectively.

RESULTS AND DISCUSSION

The results of the spin tests are presented in tables VII to XX. Results of right and left spins were quite similar and results for right spins are arbitrarily presented (glider turning to pilot's right). The results of the spin-recovery parachute tests are presented in table XXI, and the results of the longitudinal-trim tests are presented in table XXII. Tables XXIII to XXV contain the tumbling test results.

Spin Tests - Minimum Flying Weight

Normal condition.- The results of the tests for the minimum flying weight condition with the spoilers neutral are presented in table VII. When the controls were set for the normal spinning configuration (elevator full up, ailerons neutral, and rudder full with the spin), a motion oscillatory in roll and pitch took place, with approximately four oscillations per turn of the spin. Although this motion resembled a wide radius spiral, a definite condition of equilibrium appeared to

be present. Reversal of the rudder stopped the rotation
in less than one turn, but the model remained in a
stalled glide.

Deflecting the ailerons with the spin generally
retarded recoveries slightly. Setting the ailerons
against the spin was favorable in that the model would
not spin when the elevators were neutral or down. When
launched with rotation into the tunnel for these latter
two conditions, the model oscillated violently and turned
over into an inverted attitude. For the spins obtained,
the approximate average rate of descent was 120 feet per
second, full scale, and the approximate average rate of
rotation was $\frac{1}{6}$ revolution per second, full scale.

Simultaneous full reversal of the rudder and ele-
vators for all elevator-up spins resulted in rapid
recoveries in which the model went into a steep dive and
then over onto its back.

Extension of the spoilers generally decreased the
oscillations and caused the model to stop rotating, even
when the rudder was full with the spin (table VIII).
When the elevators were up, however, the model remained
in a stalled glide after the rotation ceased; reversal
of the elevators from full up to full down after rotation
had ceased caused the model to go into a steep dive.
When the elevators were down, a spin could be obtained
from which a rapid recovery was effected by full rudder
reversal.

The results of tests of the model simulating the
condition in which the landing gear has been jettisoned
are presented in table IX.

These results, when compared with those with the
landing gear installed, show a slight adverse effect on
the spin and recovery characteristics of jettisoning the
landing gear.

There was little effect of increasing the wing
dihedral from 2° to 8° (results in table X).

Mass variations.- The results of tests with moderate
mass variations (I_X and I_Z decreased 20 percent I_X,
and I_Z increased 17 percent I_X from the normal minimum
flying weight condition) are presented in tables XI

and XII. These results are somewhat similar to those
obtained with the model in the normal minimum flying
weight condition. After being launched in a spinning
attitude, the model usually went into a flat stalled
attitude, oscillatory about all three axes sometimes
with rotation about the vertical spinning axis and some-
times with little or no rotation about the vertical
axis. The rotation was stopped by rapid rudder reversal,
but the model remained in a stalled glide when the ele-
vators were up or neutral. Results of longitudinal-trim
tests indicated that movement of the elevator to the
full-down position (20°) after rotation had ceased
would have undoubtedly pitched the model into a steep
dive.

Center-of-gravity movements.- When the center-of-
gravity location was 5 percent of the mean aerodynamic
chord rearward of normal (table XIII), the spin and
recovery characteristics were similar to those with
normal center-of-gravity positions, except that when
the elevators were only 10° down, the model remained in
a stalled glide after rudder reversal. The longitudinal-
trim tests indicated that the model would recover from
this stalled glide if the elevators were moved 20° down.

When the center of gravity was moved 5 percent of
the mean aerodynamic chord forward of normal (table XIV),
the spins were oscillatory and relatively steep when the
elevators were neutral or down, but recoveries by rudder
reversal were unsatisfactory. The steep attitude of
these spins apparently made the rudder ineffective
because of shielding of the rudder by the wings and for
this reason it is not considered advisable to spin the
glider with the center of gravity forward of normal.
Recovery may be effected in this loading by holding the
elevators full up, reversing the rudder to stop rotation,
and after the rotation has stopped, fully reversing the
elevator to dive out of the stalled glide.

Inverted spins.- The results of the inverted spin
tests are presented in table XV. For inverted spins,
the designations of the control configurations are
different from those used for erect spins. "Controls
together" means that when the right rudder pedal is
forward the stick is to the pilot's right, and "controls
crossed" means that when the right rudder pedal is
forward the stick is to the pilot's left. When the
controls are together in an inverted spin, the ailerons

oppose the rolling motion; when the controls are crossed,
the ailerons aid the rolling motion. The model would
spin only with the controls crossed and the stick for-
ward for the developed spin. Rapid full rudder reversal
stopped the spinning rotation; the model, however,
remained in a flat inverted position. Movement of the
stick full back would pitch the glider from this flat
inverted glide, but results indicate that care should be
exercised to avoid entering an erect spin when the stick
is moved full back. For the other control configurations,
the model motion was very oscillatory and the model went
into an inverted glide or dive with stick forward and
into an erect position with stick neutral and back even
though the rudder was held full with the spin.

Spin Tests - Fully Loaded

The results of tests of the model in the fully
loaded condition are presented in tables XVI to XX. In
general, the results were quite similar to those of the
model in the minimum flying weight condition for both
erect and inverted spins.

Spin-Recovery Parachute Tests

The results of tests to determine the optimum size
of, and towline length for, spin-recovery tail parachutes
(table XXI) indicate that a 4.5-foot (flat circular) tail
parachute with a 27-foot towline will produce satis-
factory recoveries for the minimum flying weight con-
dition. A 7.5-foot diameter tail parachute with 27-foot
towline will be satisfactory for the fully loaded con-
dition. These results are based on tests with silk
parachutes having a drag coefficient of approximately 0.7.

Longitudinal-Trim Tests

The results of the longitudinal-trim tests of the
model presented in table XXII appear to be in good agree-
ment with the results of the spin tests. When the center
of gravity was at the normal location (14 percent M.A.C.)
the model trimmed only at positive angles of attack when
the elevators were full up and only at negative angles
of attack when the elevators were down 10°. However,

when the elevators were only $7\frac{1}{2}^{\circ}$ down, the model
trimmed at both negative and positive angles of attack,
and from the results it appeared that a down-elevator
setting of 10° was barely enough to prevent trim con-
ditions at a positive angle of attack. Trim in the
normal flight range of angles of attack could not be
obtained with the elevators neutral. Brief force tests
in the Langley free-flight tunnel indicated that the
spin-tunnel model would trim in the normal flight range
of angles of attack only with small down-elevator settings.
The results of the Langley free-flight tunnel tests and
results of Wright Field tests in their 5-foot tunnel are
compared in figure 5. The free-flight tunnel tests
showed an earlier stall and an upward shift of the
pitching-moment curves in the positive direction, and
indicated that small elevator-down deflections were
needed for trim in the normal flight range. Additional
longitudinal trim tests with small elevator-down settings
showed this tendency to trim in the normal flight range
for the spin-tunnel model.

The position of the spoilers and disposition of the
landing gear had no effect on the general trimming
characteristics of the model with the center of gravity
located at 14 percent of the mean aerodynamic chord.

When the center of gravity was located at 19 percent
of the mean aerodynamic chord and the landing gear was
off, the results indicate that more than 20° of down
elevator is necessary in order to prevent the model from
trimming at relatively large positive angles of attack
for this condition. Otherwise, the results of the trim
tests with the center of gravity moved rearward of normal
were very similar to those with the center of gravity at the
normal location.

Tumbling Tests

Minimum flying weight condition.- The results of
the tumbling tests in which the model was released with-
out initial rotation from a nose-up position to simulate
a whip-stall condition are presented in table XXIII.
The model did not tumble for any control configuration,
but executed a series of extreme oscillations in pitch
during which the model would pitch through almost $\pm 180^{\circ}$
measured from the nose-down attitude. An attempt was

made, by means of the film records of these tests, to
determine if these oscillations damped out. No damping
effect could be observed in the short distance the model
had to fall before hitting the safety net (approximately
12 feet).

The results of the tumbling tests in which the
model was given initial rotation about the wing axis are
presented in table XXIV. For all conditions tested, the
model continued to tumble in a positive (nose up)
direction when the elevators were up and in the negative
(nose down) direction when the elevators were down. The
model stopped tumbling, however, when the elevators were
set against the pitching motion. With the elevators
neutral, the model continued to tumble in either direction
when the landing gear was on and the spoilers were
retracted when the center of gravity was normal or 5 per-
cent of the mean aerodynamic chord rearward of normal.
For the normal center-of-gravity location, when the
landing gear was on and the spoilers were extended, the
model would tumble in the negative direction with the
elevators neutral. Similarly, the model would tumble in
the negative direction with neutral elevator when the
landing gear was off and the spoilers were closed. When
the center of gravity was 5 percent of the mean aero-
dynamic chord forward of normal, however, the model
would not tumble with elevators neutral.

Fully loaded condition.- The results of tumbling
tests of the model in the fully loaded condition are
presented in table XXV. For these tests, the model was
given initial rotation about the wing axis. The model
stopped tumbling when the elevators were set against the
rotation, but generally, continued to tumble for other
elevator positions. The results obtained were generally
similar to those obtained with the model in the minimum
flying weight condition (with pilot and landing gear).

CONCLUSIONS

Based on the results of tests of $\frac{1}{17.8}$-scale models
of the XFG-1 glider, the following conclusions regarding

the spin and recovery and tumbling characteristics of
the glider at a test altitude of 15,000 feet have been
made:

1. The motion of the glider in a spin will be
oscillatory about all three axes. The rotation can be
terminated satisfactorily by reversing the rudder, but
the elevator must also be moved to a down position of
20° to insure nosing down from the stalled attitude.
Care should be exercised by the pilot, however, in order
to avoid entering an inverted spin.

2. Extending the spoilers will decrease the
oscillations and cause the glider to stop rotating when
the elevators are up or neutral even if the rudder is
held full with the spin.

3. Jettisoning the landing gear or moving the
center of gravity 5 percent of the mean aerodynamic
chord forward or rearward of normal will have an adverse
effect on recovery characteristics.

4. Increasing the wing dihedral or varying the
mass distribution moderately will have no appreciable
effect on the spin and recovery characteristics.

5. The glider will spin inverted only when the
stick is forward. The rotation can be stopped satis-
factorily by reversing the rudder, but the stick must
be moved back to insure nosing out of the stalled
inverted position. Care should be taken to avoid
entering an erect spin when the stick is moved full
back.

6. A 4.5-foot diameter silk parachute with a
27-foot towline for the minimum flying weight condition,
and a 7.5-foot diameter silk parachute with a 27-foot
towline for the fully loaded condition will give satis-
factory recoveries by parachute action alone.

7. The glider will tumble, but the tumbling motion can be stopped by deflecting the elevators against the rotation.

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TABLE I

DIMENSIONAL CHARACTERISTICS OF THE

CORNELIUS XFG-1 FUEL GLIDER

Wing span, ft 54
Length over all, ft 29.4

Wing:
    Area, sq. ft 356
    Incidence, deg
        Root. 0
        Tip 1.5
    Aspect ratio 8
    Dihedral (variable) along
        quarter chord, deg. . . . . 2 to 8
    Sweepforward at quarter chord, deg 15
    Mean aerodynamic chord, in.. . . . . .85.82

Ailerons (unbalanced):
    Area, sq ft. 31.6
    Span, in.. . . . . 171.25
    Chord (rearward of hinge line),
        percent wing chord. 20

Elevator:
    Area, sq ft. 36.4
    Span, in. 107
    Chord (rearward of hinge line),
        percent wing chord. 25

Vertical tail:
    Area, sq ft. 43.5
    Span (from ℄ of glider), in. 125
    Rudder area, sq ft 19.4

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TABLE II

SPIN TEST CONDITIONS FOR THE $\frac{1}{17.8}$ -SCALE

MODEL OF THE XFG-1 GLIDER

No.	Loading	Mass variation	Landing gear	Spoilers	Modification	Type of spin	Data on table
1	Minimum flying weight	None	On	Neutral	None	Erect	VII
2	------do------	---------do---------	----do----	Extended	-----do-----	---do---	VIII
3	------do------	---------do---------	Jettisoned	Neutral	-----do-----	---do---	IX
4	------do------	I_X and I_Z decreased 20 percent of I_X	On	---do---	-----do-----	---do---	X
5	------do------	I_X and I_Z increased 17 percent of I_X	----do----	---do---	-----do-----	---do---	XI
6	------do------	c.g. rearward 5 percent of M.A.C.	----do----	---do---	-----do-----	---do---	XII
7	------do------	c.g. forward 5 percent of M.A.C.	----do----	---do---	-----do-----	---do---	XIII
8	------do------	None	----do----	---do---	-----do-----	Inverted	XIV
9	------do------	---------do---------	----do----	---do---	Wing dihedral changed from 2° to 8°	Erect	XV
10	------do------	---------do---------	----do----	---do---	Spin-recovery parachutes	---do---	XXI
11	Full load	---------do---------	----do----	---do---	None	---do---	XVI
12	------do------	---------do---------	----do----	Extended	-----do-----	---do---	XVII
13	------do------	---------do---------	Jettisoned	Neutral	-----do-----	---do---	XVIII
14	------do------	c.g. forward 5 percent of M.A.C.	On	---do---	-----do-----	---do---	XIX
15	------do------	None	----do----	---do---	-----do-----	Inverted	XX
16	------do------	---------do---------	----do----	---do---	Spin-recovery parachutes	Erect	XXI
17	------do------	c.g. rearward 5 percent of M.A.C.	----do----	---do---	-----do-----	---do---	XXI

TABLE III.- WEIGHTS, CENTER-OF-GRAVITY LOCATIONS, AND MOMENTS OF INERTIA

FOR VARIOUS LOADINGS POSSIBLE ON THE XFG-1 GLIDER

[a]Loading	Weight (lb)	Center-of-gravity location		Moments of inertia (slug-ft^2)			μ at 15,000 ft	μ at sea level	Mass parameters		
		$x/\bar{c}$	$z/\bar{c}$	I_X	I_Y	I_Z			$\dfrac{I_X - I_Y}{mb^2}$	$\dfrac{I_Y - I_Z}{mb^2}$	$\dfrac{I_Z - I_X}{mb^2}$
[1]Minimum flying weight with pilot and landing gear	3881.2	0.14	-0.051	5139	4446	8775	4.20	2.65	19.7×10^{-4}	-122.7×10^{-4}	103.0×10^{-4}
[2]Minimum flying weight with pilot and 25 gallons of gasoline	3599.3	.16	-.087	4798	4436	8635	3.85	2.45	11.1×10^{-4}	-128.6×10^{-4}	117.5×10^{-4}
[3]Minimum flying weight without pilot	3681.2	.19	-.055	5133	4131	8455	3.96	2.49	30.1×10^{-4}	-130.1×10^{-4}	99.9×10^{-4}
[5]Full load with pilot and landing gear	7997.2	.14	-.022	5387	4935	9253	8.61	5.43	6.3×10^{-4}	-59.7×10^{-4}	53.5×10^{-4}
[4]Full load without pilot and landing gear	7782.2	.19	-.036	4905	4329	8505	8.40	5.30	8.2×10^{-4}	-59.2×10^{-4}	51.0×10^{-4}
[6]Full load with pilot, without landing gear	7602.2	.13	-.033	5293	4840	9249	8.19	5.16	6.6×10^{-4}	-64.1×10^{-4}	57.5×10^{-4}

[a]Numbers correspond to numbered points on figure 4.

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TABLE IV.- FULL-SCALE VALUES OF THE WEIGHTS, CENTER-OF-GRAVITY LOCATIONS,

AND MOMENTS OF INERTIA FOR THE LOADINGS TESTED ON THE XFG-1 MODEL

[a]Loading	Weight (lb)	Center-of-gravity location		Moments of inertia (slug-ft²)			μ at 15,000 ft	μ at sea level	Mass parameters		
		$x/\bar{c}$	$z/\bar{c}$	I_X	I_Y	I_Z			$\dfrac{I_X - I_Y}{mb^2}$	$\dfrac{I_Y - I_Z}{mb^2}$	$\dfrac{I_Z - I_X}{mb^2}$
[1]Minimum flying weight with pilot and landing gear	3846	0.14	-0.052	5084	4369	9365	4.13	2.61	20.3×10^{-4}	-143.5×10^{-4}	123.2×10^{-4}
[2]Minimum flying weight with pilot, landing gear jettisoned	3507	.12	-.035	4789	4275	9096	3.79	2.38	16.2×10^{-4}	-152.0×10^{-4}	135.8×10^{-4}
[4]Minimum flying weight with pilot and landing gear (c.g. rearward 5 percent MAC.)	3846	.19	-.052	5084	3844	8840	4.13	2.61	35.6×10^{-4}	-143.5×10^{-4}	107.9×10^{-4}
[3]Minimum flying weight with pilot and landing gear (c.g. forward 5 percent M.A.C.)	3846	.09	-.052	5084	4864	9860	4.13	2.61	6.3×10^{-4}	-143.5×10^{-4}	137.2×10^{-4}
[5]Minimum flying weight with pilot and landing gear (I_X & I_Z increased 17.2 percent of I_X)	4004	.14	-.058	5941	4369	10222	4.30	2.71	43.3×10^{-4}	-161.3×10^{-4}	118.0×10^{-4}
[6]Minimum flying weight with pilot and landing gear (I_X & I_Z decreased 20 percent of I_X)	3890	.14	----	4060	4369	8340	4.20	2.65	-8.7×10^{-4}	-112.5×10^{-4}	121.2×10^{-4}
[1]Full load with pilot and landing gear	7886	.14	-.010	5664	4738	10204	8.51	5.35	13.0×10^{-4}	-76.6×10^{-4}	63.6×10^{-4}
[2]Full load with pilot, landing gear jettisoned	7547	.12	-.023	5384	4655	9930	8.13	5.11	10.7×10^{-4}	-77.4×10^{-4}	66.7×10^{-4}
[3]Full load with pilot and landing gear (c.g. forward 5 percent M.A.C.)	7886	.08	-.010	5664	5738	11203	8.51	5.35	-1.0×10^{-4}	-76.6×10^{-4}	77.6×10^{-4}

[a]Numbers correspond to numbered points on figure 4.

TABLE V

LONGITUDINAL-TRIM TEST CONDITIONS ON

THE $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER

No.	Center-of-gravity location percent M.A.C.	Landing gear	Spoilers	Data on table
1	14	On	Neutral	XXII
2	14	----do----	Extended	
3	14	Jettisoned	Neutral	
4	14	----do----	Extended	
5	19	On	Neutral	
6	19	----do----	Extended	
7	19	Jettisoned	Neutral	
8	19	----do----	Extended	

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TABLE VI

TUMBLING TEST CONDITIONS ON THE $\frac{1}{17.8}$-SCALE

MODEL OF THE XFG-1 GLIDER

No.	Loading	Mass variation	Landing gear	Spoilers	Data on table
1	Minimum flying weight	None	On	Neutral	XXIII & XXIV
2	------do------	---------do--------	Jettisoned	---do---	XXIV
3	------do------	---------do--------	On	Extended	
4	------do------	c.g. forward 5 percent of M.A.C.	-----do------	Neutral	
5	------do------	c.g. rearward 5 percent of M.A.C.	-----do------	---do---	
6	Full load	None	-----do------	---do---	XXV

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TABLE VII.- RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER

IN THE MINIMUM FLYING WEIGHT CONDITION WITH SPOILERS NEUTRAL

[Model launched erect with spinning rotation, rudder full right; indicated controls reversed]

Elevator setting	Aileron setting	Description of model motion (before control reversal)	Flight path (after full rudder reversal)	Flight path (after simultaneous full reversal of rudder and elevator)	Flight path (after elevator reversal)
Full up	Full against	Extremely oscillatory; alternate rolling and yawing motion	Made from 1/4 to 3/4 of a turn and went into stalled glide	Made from 1/4 to 1/2 of a turn and went into steep glide or dive	Made 1/4 of a turn and went into steep glide or dive
Do----	Neutral	Very oscillatory, inner wing dropped and model yawed into spin	Made from 1/4 to 1/2 of a turn and went into stalled glide	Made 1/4 of a turn and went into steep glide or inverted spin	Made from 1/4 to 1 turn and went into steep glide or dive
Do----	Full with	Extremely oscillatory; alternate rolling and yawing motion	Made 1/4 of a turn and went into a stalled glide	Made 1/4 of a turn and went into dive	Made from 1/4 to 1/2 of a turn and went into steep glide or dive
Neutral	Full against	Pitched and rolled onto back; went into left spin when launched with rudder against rotation	--------	----------	--------
Do----	Neutral	Very oscillatory, inner wing dropped and model yawed into spin	Made 1/4 of a turn and went into stalled glide	----------	--------
Do----	Full with	----------do---------	Made 1/4 to 1 turn and went into stalled glide	----------	--------
Down (10°)	Full against	Pitched into dive	--------	----------	--------
Do----	Neutral	Extremely oscillatory; alternate rolling and yawing motions	Would probably have gone on its back after approx. $1\frac{1}{2}$ turns	----------	--------
Do----	Full with	----------do---------	Made 1/2 of a turn and rolled on back	----------	--------

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TABLE VIII

RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER

IN THE MINIMUM FLYING WEIGHT CONDITION WITH SPOILERS EXTENDED

[Model launched erect with spinning rotation, rudder full right; indicated controls reversed]

Elevator setting	Aileron setting	Description of model motion (before control reversal)	Flight path (after full rudder reversal)	Flight path (after full elevator reversal)
Full up	Full against	Stalled glide	------	------
Do----	Neutral	---------do---------	------	Went into steep dive
Do----	Full with	---------do---------	------	Went into erect spin or inverted dive
Neutral	Full against	---------do---------	------	------
Do----	Neutral	---------do---------	------	------
Do----	Full with	---------do---------	------	------
Down (10°)	Full against	Pitched into dive	------	------
Do----	Neutral	Extremely oscillatory, alternate rolling and yawing motion	Made 1/4 turn and pitched into a dive	------
Do----	Full with	---------do---------	------	------

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TABLE IX

RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER IN THE

MINIMUM FLYING WEIGHT CONDITION WITH THE LANDING GEAR JETTISONED

[Spoilers neutral; model launched erect with spinning rotation, rudder full right; rudder reversal from full right to full left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Full up (30°)	Full against	Periodically pitched from a flat to a steep attitude	Steep glide, extremely oscillatory in roll and pitch
Do-------	Neutral	Stalled glide, extremely oscillatory in roll	Same as before reversal
Do-------	Full with	Spin very oscillatory in roll and pitch	Made 1/2 of a turn and went into stalled glide
Neutral	Full against	Rolled and pitched on back	Rolled into dive
Do-------	Neutral	Stalled glide, very oscillatory in roll	Same as before reversal
Do-------	Full with	------------do------------	----------do----------
Full down (10°)	Full against	Rolled and yawed into dive or onto back	Stalled glide, extremely oscillatory in roll
Do-------	Neutral	Stalled glide, very oscillatory in yaw and pitch	Stalled glide
Do-------	Full with	Stalled glide	------

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TABLE X

RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER

IN THE MINIMUM FLYING WEIGHT CONDITION WITH INCREASED WING DIHEDRAL

[Spoilers neutral; wing dihedral increased to 8°; model
launched erect with spinning rotation, rudder full right;
rudder reversal from full right to full left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Full up	Full with	Stalled spiral glide	Straight stalled glide approximately 1/4 turn after reversal
Do----	Neutral	-----------do-------------	Do.
Do----	Full against	-----------do-------------	Do.
Neutral	Full with	Wandering, wide radius spin	Stalled glide $1\frac{3}{4}$ turns after reversal
Do----	Neutral	-----------do-------------	Stalled glide 3/4 turn after reversal
Do----	Full against	-----------do-------------	Stalled glide 1/2 turn after reversal
Full down (20°)	Full with	Spin very oscillatory in pitch and yaw (made approximately 1 turn in flat attitude and 2 in steep attitude, then repeated)	Same as before reversal

TABLE X - Concluded

RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE

MODEL OF THE XFG-1 GLIDER -Concluded

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Full down (20°)	Neutral	Steep spin	Went into inverted stalled glide approximately $4\frac{1}{2}$ turns after reversal
Do----	Full against	Went inverted	-------

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TABLE XI

RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER IN THE

MINIMUM FLYING WEIGHT CONDITION WITH MASS RETRACTED LATERALLY

[I_X and I_Z decreased 20 percent of I_X from normal; spoilers neutral;
model launched erect with spinning rotation, rudder full right;
rudder reversal from full right to full left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Full up	Full against	Stalled glide, extremely oscillatory in roll, pitch, and yaw	Stalled glide, very oscillatory in roll; rotation stopped in 1 turn
Do----	Neutral	------------do------------	Stalled glide, extremely oscillatory in roll; rotation stopped in 3/4 of a turn
Do----	Full with	Stalled glide, extremely oscillatory in roll	Same as before reversal
Neutral	Full against	------------do------------	Do.
Do----	Neutral	Steep dive	Stalled glide, very oscillatory in roll
Do----	Full with	Stalled glide	Same as before reversal
Full down (10°)	Full against	Model yawed and pitched into steep dive	Do.
Do----	Neutral	Steep glide, very oscillatory in roll	Stalled glide
Do----	Full with	Stalled glide, sometimes dived into inverted position	Model went into dive

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TABLE XII

RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER

IN THE MINIMUM FLYING WEIGHT CONDITION WITH MASS EXTENDED LATERALLY

[I_X and I_Z increased 17 percent of I_X from normal; spoilers neutral;
model launched erect with spinning rotation, rudder full right;
rudder reversal from full right to full left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Full up (30°)	Full against	Stalled glide, extremely oscillatory in roll, yaw, and pitch	Stalled glide, very oscillatory in roll
Do----	Neutral	------------do------------	Do.
Do----	Full with	------------do------------	Do.
Neutral	Full against	Model rolled and yawed into steep dive	Same as before reversal
Do----	Neutral	Moderately steep spin, very oscillatory in roll	Made $1\frac{1}{2}$ turns and went into steep stalled glide
Do----	Full with	Stalled glide, yawed and banked	Stalled glide
Full down (10°)	Full against	Rolled and yawed into steep dive	Dive
Do----	Neutral	Very oscillatory spin, whipping motion in roll and yaw	Made more than 1 turn and went into dive
Do----	Full with	------------do------------	--------

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TABLE XIII

RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER
IN THE MINIMUM FLYING WEIGHT CONDITION WITH THE CENTER OF GRAVITY
MOVED 5 PERCENT REARWARD OF NORMAL

[Spoilers neutral; model launched erect with spinning rotation,
rudder full right; rudder reversal from full right to full left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Full up	Full against	Violently oscillatory in roll, yaw, and pitch	-------
Do-------	Neutral	Stalled glide, very oscillatory in roll and yaw	-------
Do-------	Full with	Stalled glide, very oscillatory in roll	-------
Neutral	Full against	Pitched and rolled onto back	-------
Do-------	Neutral	Stalled glide, very oscillatory in roll, sometimes rolled onto back	-------
Do-------	Full with	Stalled glide, very oscillatory in roll	-------
Full down (10°)	Full against	Rolled and pitched onto back	-------
Do-------	Neutral	Rolled and pitched into vertical or inverted position	-------
Do-------	Full with	Stalled glide, slightly oscillatory in roll	-------

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TABLE XIV

RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER

IN THE MINIMUM FLYING WEIGHT CONDITION WITH THE CENTER OF GRAVITY
MOVED 5 PERCENT FORWARD OF NORMAL

[Model launched erect with spinning rotation, rudder
full right; rudder reversal from full right to full left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Full up (30°)	Full against	Stalled glide	Stalled glide, oscillatory in roll
Do----	Neutral	------------do-------------	Same as before reversal
Do----	Full with	------------do-------------	Dive or stalled glide
Neutral	Full against	Steep wandering and very oscillatory spin with whip	Same as before reversal
Do-----	Neutral	------------do-------------	Went into a steep dive in greater than $1\frac{1}{4}$ turns
Do-----	Full with	------------do-------------	-------
Full down (10°)	Full against	Steep spin, extremely wandering and oscillatory	Same as before reversal
Do---	Neutral	Steep wandering and oscillatory spin with whip	Went into inverted dive
Do-----	Full with	------------do-------------	Same as before reversal

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TABLE XV

RESULTS OF INVERTED SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL

OF THE XFG-1 GLIDER IN THE MINIMUM FLYING WEIGHT CONDITION

[Spoilers neutral; model launched inverted with spinning
rotation, rudder full to pilot's right; rudder reversal
from full to pilot's right to full to pilot's left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	[1]Flight path (after rudder reversal)
Stick full forward	Stick full right (controls together)	Inverted glide oscillatory in yaw	Made 1/4 of a turn and glided inverted
Do-----	Stick neutral	Very oscillatory in yaw, pitched into erect position	Made 1/4 of a turn and dived inverted
Do-----	Stick full left (controls crossed)	Spin very oscillatory in roll and yaw	Do.
Stick neutral	Stick full right (controls together)	Oscillatory, pitched into erect stalled glide	Made 1/4 of a turn and dived into erect position

[1]Rudder reversed while model was in flat attitude due to launching rotation

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TABLE XV - Concluded

RESULTS OF INVERTED SPIN TESTS - Concluded

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	[1]Flight path (after rudder reversal)
Stick neutral	Stick neutral	Oscillatory, pitched into erect position; erect stalled glide once	Made 1/4 of a turn and went into erect stalled glide
Do----	Stick full left (controls crossed)	Oscillatory, pitched into erect position	Made 1/4 of a turn and dived inverted
Stick full back	Stick full right (controls together)	Oscillatory, pitched into erect stalled glide	Made from 1/4 to 1/2 of a turn and dived into erect stalled glide
Do----	Stick neutral	------------do------------	Made 1/2 of a turn and dived into erect position
Do----	Stick full left (controls crossed)	------------do------------	- Do.

[1]Rudder reversed while model was in flat attitude due to launching rotation

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TABLE XVI

RESULTS OF SPIN TESTS OF A $\dfrac{1}{17.8}$-SCALE MODEL

OF THE XFG-1 GLIDER IN THE FULLY LOADED CONDITION

[Spoilers neutral; model launched erect with spinning rotation, rudder
full right; rudder reversal from full right to full left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Full up	Full with	Stalled spiral glide	-------
Do----	Neutral	Stalled glide	-------
Do----	Full against	-------------do-------------	-------
Neutral	Full with	Spiral dive	-------
Do----	Neutral	Made 1/2 turn, dived a short distance; motion is repeated	Same as before reversal
Do----	Full against	Very oscillatory with wide radius; might be spin or spiral glide	Made 1/4 turn and glided (moderately steep)
Full down (20°)	Full with	Wandering spin with large pitching oscillations; very steep	Made 1 to $2\frac{1}{2}$ turns and went into inverted spins
Do----	Neutral	-------------do-------------	Same as before reversal
Do----	Full against	Pitched into inverted spin	-------

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TABLE XVII

RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER

IN THE FULLY LOADED CONDITION WITH SPOILERS EXTENDED

[Model launched erect with spinning rotation, rudder
full right; reversal from full right to full left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Full up	Full with	Spiral glide	-------
Do----	Neutral	-------------do-------------	-------
Do----	Full against	-------------do-------------	-------
Neutral	Full with	-------------do-------------	Same as before reversal
Do----	Neutral	-------------do-------------	Do.
Do----	Full against	Wandering spin; one yawing oscillation per turn of spin	Made 1/2 turn and went into stalled glide
Full down (20°)	Full with	Spiral dive	Made 1/4 turn and went into inverted dive
Do----	Neutral	-------------do-------------	Made 3/4 turn and went into inverted dive
Do----	Full against	Went into inverted spin	-------

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TABLE XVIII

RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER

IN THE FULLY LOADED CONDITION WITH LANDING GEAR JETTISONED

[Spoilers neutral; model launched erect with spinning rotation, rudder full right; rudder reversal from full right to full left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Full up	Full with	Stalled glide	-------
Do-----	Neutral	-------------do-------------	-------
Do-----	Full against	-------------do-------------	-------
Neutral	Full with	Wide spiral glide oscillatory in pitch	Same as before reversal
Do-----	Neutral	-------------do-------------	Do.
Do-----	Full against	Wide radius spin	Made 1/2 turn and dived
Full down (20°)	Full with	Spin, oscillatory in roll, pitch, and yaw	Same as before reversal
Do-----	Neutral	Spin, oscillatory in pitch and yaw	Do.
Do-----	Full against	Spin, oscillatory in roll, pitch, and yaw	Made 3/4 turn and went into stalled glide; or made 1/4 turn and went into steep inverted dive

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TABLE XIX

RESULTS OF SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER IN THE

FULLY LOADED CONDITION WITH THE CENTER OF GRAVITY MOVED 5 PERCENT FORWARD OF NORMAL

[Spoilers neutral; model launched erect with spinning rotation, rudder full right; rudder reversal from full right to full left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Full up	Full with	Went into a stalled glide	-------
Do----	Neutral	------------do-------------	-------
Do----.	Full against	------------do-------------	-------
Neutral	Full with	Steep spin	Same as before reversal
Do----.	Neutral	------------do-------------	Do.
Do----	Full against	------------do-------------	Dived out after approximately 1 turn

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TABLE XX

RESULTS OF INVERTED SPIN TESTS OF A $\frac{1}{17.8}$-SCALE MODEL

OF THE XFG-1 GLIDER IN FULLY LOADED CONDITION

[Spoilers neutral; model launched inverted with spinning
rotation, rudder full to pilot's right; rudder reversal
from full to pilot's right to full to pilot's left]

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Stick full forward	Stick full right (controls together)	Went into erect dive	Model immediately rolled with ailerons into erect position, pitched into inverted position, pitched back into erect position and dived.
Do----	Stick neutral	Spun with violent rolling and pitching oscillations	Came out in a steep erect or inverted dive after 1/4 turn, model tended to pitch into flat inverted position
Stick neutral	Stick full right (controls together)	Went erect	-------

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TABLE XX-- Concluded

RESULTS OF INVERTED SPIN TESTS - Concluded

Elevator setting	Aileron setting	Description of model motion (before rudder reversal)	Flight path (after rudder reversal)
Stick neutral	Stick neutral	Went erect	-------
Stick full back	Stick full right (controls together	---------do---------	-------
Do----	Stick neutral	---------do---------	-------
Do----	Stick full left (controls crossed)	Increased rolling oscillations caused model to go into erect stalled glide	-------

TABLE XXI

EFFECT OF SPIN-RECOVERY PARACHUTES ON RECOVERY

CHARACTERISTICS OF MODELS OF THE XFG-1 GLIDER

[Loading as indicated; parachute towline attached to tailcone; spoilers closed; ailerons neutral; recovery attempted by opening parachute; rudder full with the spin during recovery attempt; right erect spins]

Elevator position	Center-of-gravity position, percent M.A.C	Parachute data		Rate of vertical descent (fps) (full-scale) (a)	Turns for recovery
		Diameter (feet) (full scale)	Towline length (feet) (full scale)		
Minimum flying weight					
Full up	14	3.6	27	150	$\frac{1}{2}$, $^b\frac{1}{2}$
Full down	14	3.6	27	150	$2\frac{1}{4}$, $2\frac{3}{4}$
Full up	14	4.5	27	150	$\frac{3}{4}$, 1
Full down	14	4.5	27	150	$1\frac{1}{4}$, $1\frac{1}{2}$

^{a}Because of the wandering and oscillatory nature of the spins, the values of the airspeed are very approximate.
^{b}Visual estimate.

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TABLE XXI - Continued

EFFECT OF SPIN-RECOVERY PARACHUTES - Continued

Elevator position	Center-of-gravity position, percent M.A.C.	Parachute data		Rate of vertical descent (fps) (full scale) (a)	Turns for recovery
		Diameter (feet) (full scale)	Towline length (feet) (full scale)		
Fully loaded					
Full up	14	5.5	27	250	$1, 1\frac{1}{4}, 2$
Full down	14	5.5	27	250	$1, 2\frac{3}{4}$
Full up	14	7.1	27	250	$\frac{1}{4}, \frac{3}{4}$
Full down	14	7.1	27	250	$1\frac{1}{4}, 2$
Full up	19	7.1	27	250	$\frac{1}{2}$
Full up	14	7.1	13.5	250	$\frac{1}{4}, \frac{1}{4}$

[a]Because of the wandering and oscillatory nature of the spins, the values of the airspeed are very approximate.

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TABLE XXI - Concluded

EFFECT OF SPIN-RECOVERY PARACHUTES - Concluded

Elevator position	Center-of-gravity position, percent M.A.C.	Parachute data		Rate of vertical descent (fps) (full scale) (a)	Turns for recovery
		Diameter (feet) (full scale)	Towline length (feet) (full scale)		
Fully loaded					
Full down	14	7.1	13.5	250	1, $1\frac{3}{4}$
Full up	19	7.1	13.5	250	No effect of parachute
Full down	19	7.1	13.5	250	$\frac{1}{4}$, $\frac{3}{4}$

[a]Because of the wandering and oscillatory nature of the spins, the values of the airspeed are very approximate.

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TABLE XXII.- RESULTS OF LONGITUDINAL-TRIM TESTS

OF THE $\frac{1}{17.8}$-SCALE MODEL OF THE XFG-1 GLIDER

[Minimum flying weight with pilot and landing gear; center of gravity as indicated; spoilers and landing gear as indicated; ailerons neutral; rudder neutral]

Elevator setting (deg)	Spoilers	Landing gear	C.G. location (percent MAC)	Trim angles of attack, α, deg			Remarks
				Normal flight range	Large positive	Inverted	
Free	Neutral	On	14	----	45	$-27\frac{1}{2}$	
30U	---do---	----do----	14	----	53	----	
2U	---do---	----do----	14	----	33	-25	
N	---do---	----do----	14	----	34	-26	
1D	---do---	----do----	14	0	35	$-27\frac{1}{2}$	Trimmed momentarily at 0° (approx.)
2D	---do---	----do----	14	----	$34\frac{1}{2}$	-29	
5D	---do---	----do----	14	----	$26\frac{1}{2}$	-34	
$7\frac{1}{2}$D	---do---	----do----	14	----	25	$-36\frac{1}{2}$	
10D	---do---	----do----	14	----	----	-37	
Free	Extended	----do----	14	----	41	-40	
30U	---do---	----do----	14	----	$62\frac{1}{2}$	----	
10U	---do---	----do----	14	----	38	-18	
5U	---do---	----do----	14	----	33	-22	
N	---do---	----do----	14	----	$32\frac{1}{2}$	$-26\frac{1}{2}$	
$2\frac{1}{2}$D	---do---	----do----	14	----	$27\frac{1}{2}$	$-26\frac{1}{2}$	
5D	---do---	----do----	14	----	25	-30	
10D	---do---	----do----	14	----	----	-39	
Free	Neutral	Jettisoned	14	----	$24\frac{1}{2}$	-28	
30U	---do---	----do----	14	----	$57\frac{1}{2}$	----	
N	---do---	----do----	14	----	26	-27	
1D	---do---	----do----	14	-3	35	-28	Trimmed momentarily at -3° (approx.) Very sensitive
2D	---do---	----do----	14	----	$32\frac{1}{2}$	-30	
3D	---do---	----do----	14	----	30	-28	
5D	---do---	----do----	14	----	25	$-32\frac{1}{2}$	
$7\frac{1}{2}$D	---do---	----do----	14	----	23	-36	Very little force required for change from erect to inverted attitude
10D	---do---	----do----	14	----	----	-36	
Free	Extended	----do----	14	----	37	-37	
30U	---do---	----do----	14	----	58	----	
N	---do---	----do----	14	----	$24\frac{1}{2}$	-30	
5D	---do---	----do----	14	----	$27\frac{1}{2}$	$-29\frac{1}{2}$	
$7\frac{1}{2}$D	---do---	----do----	14	----	24	-33	
10D	---do---	----do----	14	----	----	-44	
Free	Neutral	On	19	----	59	-55	Slightly oscillatory in both attitudes
30U	---do---	----do----	19	----	----	----	Erect attitude, too oscillatory to determine reading
N	---do---	----do----	19	----	$35\frac{1}{2}$	-45	
10D	---do---	----do----	19	----	25	----	
15D	---do---	----do----	19	----	----	$-62\frac{1}{2}$	
Free	Extended	----do----	19	----	----	----	Oscillated between -65° and $-74\frac{1}{2}$°. Did not trim at any attitude
30U	---do---	----do----	19	----	$26\frac{1}{2}$	----	Oscillated at times between $26\frac{1}{2}$° and $33\frac{1}{2}$°.
N	---do---	----do----	19	----	$35\frac{1}{2}$	----	
10D	---do---	----do----	19	----	----	-63	
Free	Neutral	Jettisoned	19	----	$46\frac{1}{2}$	-59	Both attitudes were oscillatory. Elevators were at maximum deflections for both attitudes. Erect attitudes were oscillatory sometimes.
30U	---do---	----do----	19	----	68	----	
N	---do---	----do----	19	----	39	-44	
10D	---do---	----do----	19	----	28	-56	
15D	---do---	----do----	19	----	20	-55	
20D	---do---	----do----	19	----	22	-64	
25D	---do---	----do-----	19	----	22	-69	Paused at erect attitude, then rotated into inverted attitude.
30D	---do---	----do----	19	----	----	-69	
Free	Extended	----do----	19	----	----	-51	Erect attitude, too oscillatory to determine reading. Erect attitude, was sometimes oscillatory.
30U	---do---	----do----	19	----	62	-10	
N	---do---	----do----	19	----	$37\frac{1}{2}$	-41	
10D	---do---	----do----	19	----	26	-60	Both attitudes slightly oscillatory.

TABLE XXIII

TUMBLING TESTS OF THE XFG-1 GLIDER MODEL

WITHOUT INITIAL ROTATION

[Model released in a nose-up attitude simulating a whip stall.
Minimum flying weight; spoilers neutral]

Elevator setting	Aileron setting	Rudder setting	Tunnel airspeed (full scale) (fps)	Rate of descent (full scale) (fps)	Behavior of model
30°U	N	N	38	100	Oscillated in pitch through almost ±180° measured from nose-down attitude
N	---do---	---do--	38	102	Do.
10°D	---do---	---do--	38	----	Oscillated in pitch through almost ±180° measured from nose-down attitude into erect stalled attitude
30°U	---do---	25°L	38	----	Oscillated in pitch through almost ±180° measured from nose-down attitude
N	---do---	25°L	38	----	Do.
10°D	---do---	25°L	38	----	Do.
30°U	RAD, LAU	N	49	----	Do.
N	---do---	---do--	49	----	Oscillated in pitch through almost ±180° measured from nose-down attitude into erect stalled attitude
10°D	---do---	---do--	49	----	Do.

N   - Neutral
RAD - Right aileron down
LAU - Left aileron up

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TABLE XXIV.- TUMBLING TESTS OF THE XFG-1 GLIDER MODEL WITH INITIAL ROTATION

[Model given initial pitching rotation about lateral axis
Tunnel airspeed for all tests was 63 feet per second, full scale

Model loading	Model condition	Elevator setting	Aileron setting	Rudder setting	Direction of initial pitching rotation	Rate of descent (full scale) (fps)	Behavior of model
Minimum flying weight	Landing gear on spoilers neutral	30°U	N	N	Negative	----	Stopped tumbling and pitched into dive with oscillations in pitch
Do------	-------do-------	N	---do---	---do---	----do----	96	Did not stop tumbling
Do------	-------do-------	10°D	---do---	---do---	----do----	87	Do.
Do------	-------do-------	30°U	---do---	25°L	----do----	----	Stopped tumbling and pitched into dive with oscillations in pitch
Do------	-------do-------	N	---do---	25°L	----do----	----	Did not stop tumbling
Do------	-------do-------	10°D	---do---	25°L	----do----	----	Do.
Do------	-------do-------	30°U	RAD, LAU	N	----do----	----	Stopped tumbling in inverted position and rolled to pilot's left into erect attitude
Do------	-------do-------	N	---do---	---do---	----do----	----	Did not stop tumbling
Do------	-------do-------	10°D	---do---	---do---	----do----	----	Do.
Do------	-------do-------	30°U	N	---do---	Positive	----	Do.
Do------	-------do-------	N	---do---	---do---	----do----	97	Do.
Do------	-------do-------	10°D	---do---	---do---	----do----	----	Stopped tumbling and pitched into dive with oscillations in pitch
Do------	-------do-------	30°U	---do---	25°L	----do----	----	Did not stop tumbling
Do------	-------do-------	N	---do---	25°L	----do----	----	Do.
Do------	-------do-------	10°D	---do---	25°L	----do----	----	Stopped tumbling and pitched into dive with oscillations in pitch
Do------	-------do-------	30°U	RAD, LAU	N	----do----	----	Did not stop tumbling
Do------	-------do-------	N	---do---	---do---	----do----	----	Do.
Do------	-------do-------	10°D	---do---	---do---	----do----	----	Stopped tumbling and pitched into dive with oscillations in pitch
Do------	Spoilers neutral landing gear jettisoned	30°U	N	---do---	Negative	----	Stopped tumbling and pitched into an erect stalled attitude
Do------	-------do-------	N	---do---	---do---	----do----	----	Did not stop tumbling
Do------	-------do-------	10°D	---do---	---do---	----do----	----	Do.
Do------	-------do-------	20°D	---do---	---do---	----do----	88	Do.
Do------	-------do-------	30°U	---do---	---do---	Positive	91	Do.
Do------	-------do-------	N	---do---	---do---	----do----	----	Stopped tumbling and pitched into dive with oscillations in pitch
Do------	-------do-------	10°D	---do---	---do---	----do----	----	Stopped tumbling and pitched into inverted stalled attitude
Do------	-------do-------	20°D	---do---	---do---	----do----	----	Do.
Do------	Landing gear on spoilers extended	30°U	---do---	---do---	Negative	----	Stopped tumbling and pitched into erect stalled position
Do------	-------do-------	N	---do---	---do---	----do----	----	Did not stop tumbling
Do------	-------do-------	10°D	---do---	---do---	----do----	----	Do.
Do------	-------do-------	20°D	---do---	---do---	----do----	95	Do.
Do------	-------do-------	30°U	---do---	---do---	Positive	95	Do.
Do------	-------do-------	N	---do---	---do---	----do----	----	Stopped tumbling and pitched into dive with oscillations in pitch
Do------	-------do-------	10°D	---do---	---do---	----do----	----	Do.
Do------	-------do-------	20°D	---do---	---do---	----do----	----	Do.
c.g. 5 percent forward	Landing gear on spoilers neutral	30°U	---do---	---do---	Negative	----	Do.
Do------	-------do-------	N	---do---	---do---	----do----	----	Do.
Do------	-------do-------	10°D	---do---	---do---	----do----	----	Did not stop tumbling
Do------	-------do-------	20°D	---do---	---do---	----do----	----	Do.
Do------	-------do-------	30°U	---do---	---do---	Positive	----	Do.
Do------	-------do-------	N	---do---	---do---	----do----	----	Stopped tumbling and pitched into dive with oscillations in pitch
Do------	-------do-------	10°D	---do---	---do---	----do----	----	Do.
Do------	-------do-------	20°D	---do---	---do---	----do----	----	Do.
c.g. 5 percent rearward	-------do-------	30°U	---do---	---do---	Negative	----	Do.
Do------	-------do-------	N	---do---	---do---	----do----	----	Did not stop tumbling
Do------	-------do-------	10°D	---do---	---do---	----do----	----	Do.
Do------	-------do-------	20°D	---do---	---do---	----do----	----	Do.
Do------	-------do-------	30°U	---do---	---do---	Positive	----	Do.
Do------	-------do-------	N	---do---	---do---	----do----	----	Do.
Do------	-------do-------	10°D	---do---	---do---	----do----	----	Do.
Do------	-------do-------	20°D	---do---	---do---	----do----	----	Stopped tumbling and pitched into dive with oscillations in pitch
Do------	-------do-------	30°D	---do---	---do---	----do----	----	Do.

RAD - Right aileron down
LAU - Left aileron up

TABLE XXV

TUMBLING TESTS OF A $\frac{1}{17.8}$-SCALE MODEL

OF THE XFG-1 GLIDER IN THE FULLY LOADED

CONDITION WITH INITIAL ROTATION

[Spoilers neutral; ailerons and rudder neutral;
model given initial rotation about the lateral
axis; the tests were run at an airspeed
of 102.1 feet per second, full scale]

Elevator setting	Direction of initial pitch-ing rotation	Behavior of model
Full up	Negative	Stopped tumbling and dived
Neutral	------do------	Did not stop tumbling
Full down	------do------	Do.
Full up	Positive	Do.
Neutral	------do------	Stopped tumbling and pitched into dive
Full down	------do------	Stopped tumbling

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Elevator H.L.
.75 C

Spoiler

Aileron H.L.
.80 C

6.02"

9.62"

6.19"

15°

2.53"

.51"

.13"

.44"

¼ Chord

8.52"

2.47"

⌀ TO ⌀

18.01"

⌀ Thrust

36.47"

1.58"

2°

19.86"

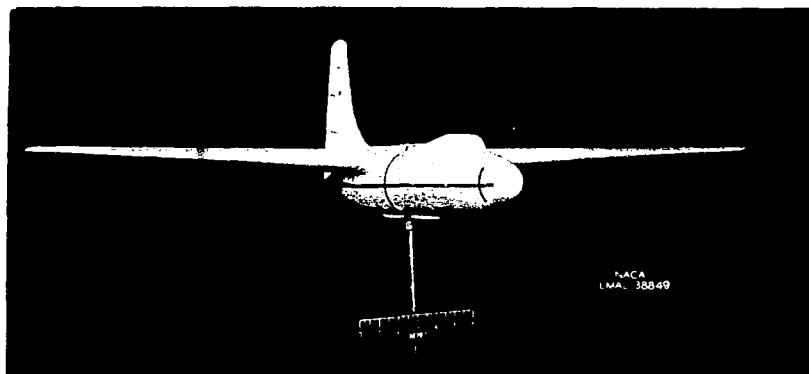9.37"

8.30"

Rudder H.L.

7.03"

.24

⌀ Thrust
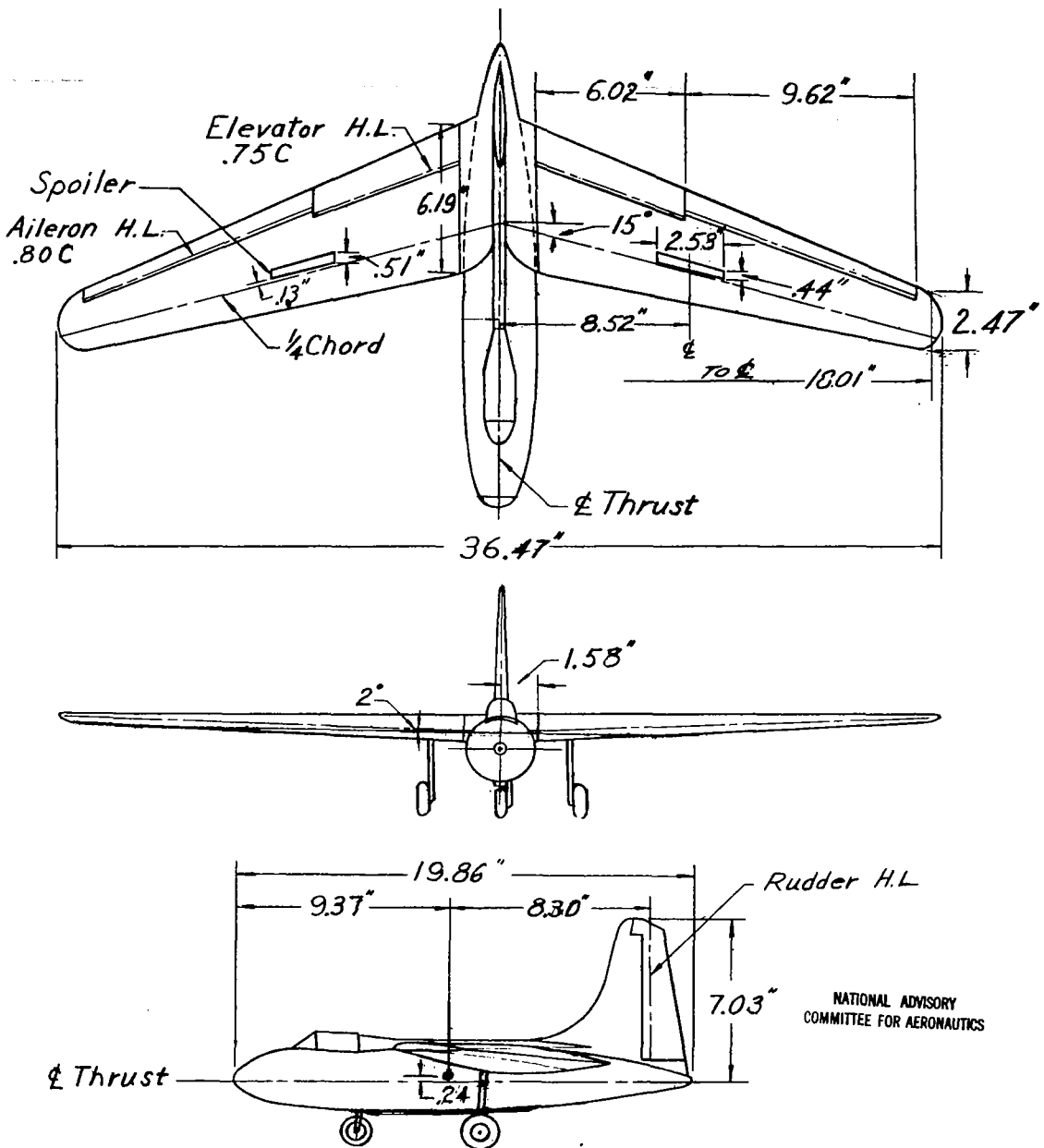
Figure 1.   Sketch of the $\frac{1}{17.8}$ scale model
of the Cornelius XFG-1 glider as tested
in the free-spinning tunnel. Center-of-
gravity position shown for the minimum
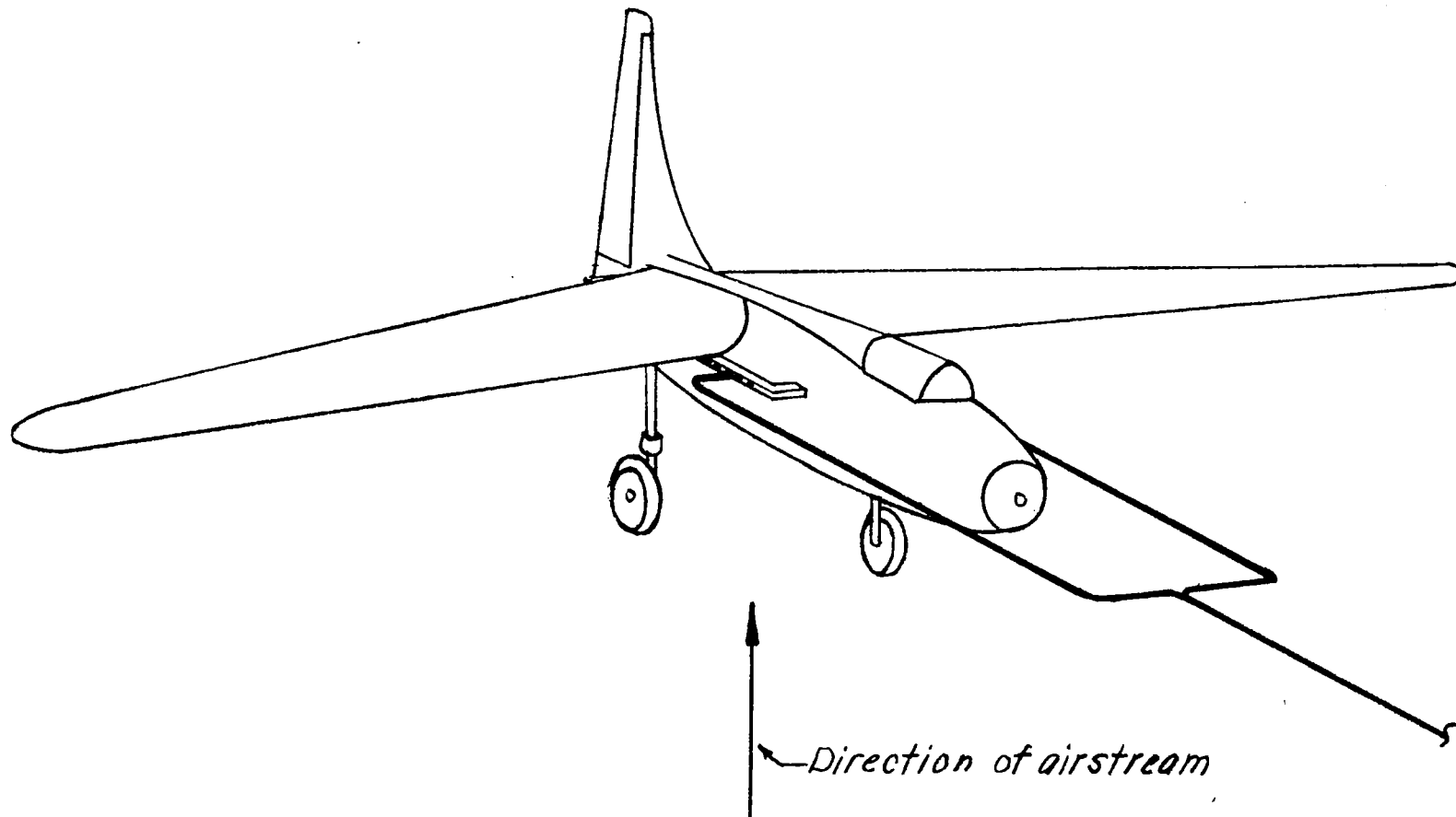flying weight condition
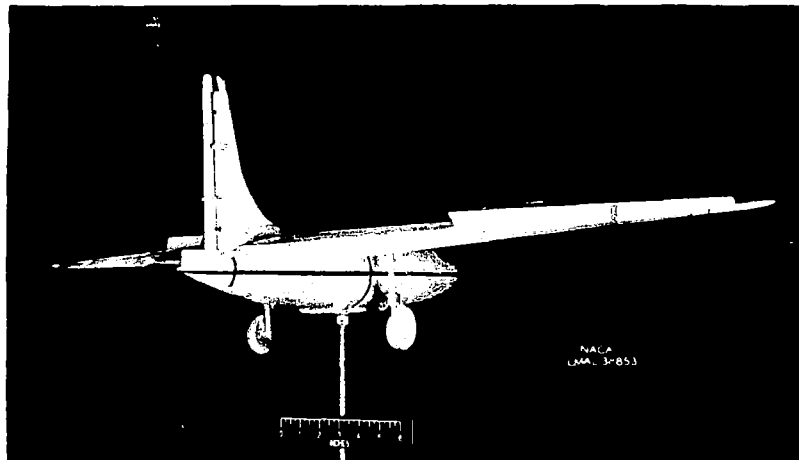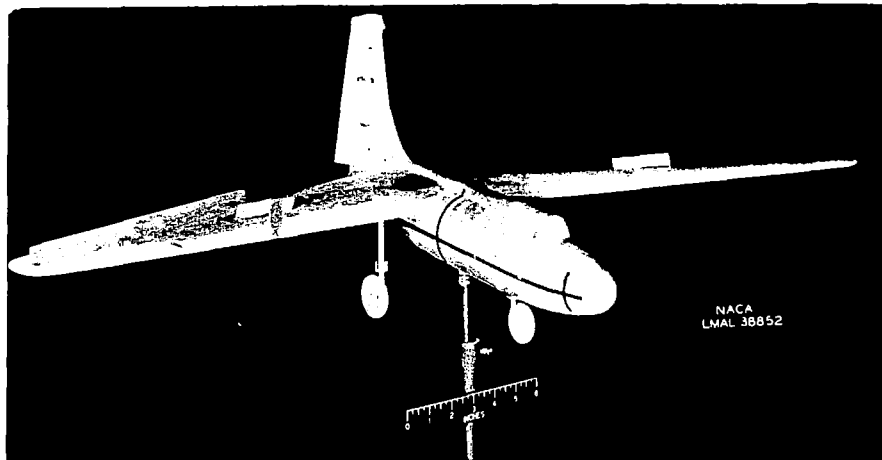
Normal condition, spoilers extended.
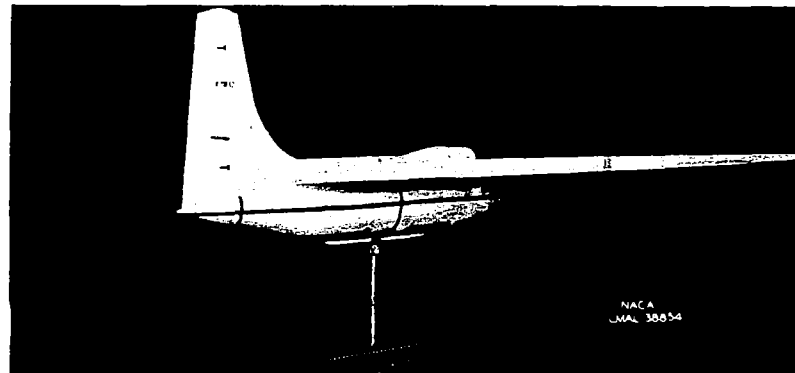
Normal condition-landing gear jettisoned.

Figure 2.- Photographs of the $\frac{1}{17.8}$-scale model of the Cornelius XFG-1 glider.

—Direction of airstream

Figure 3 .- Sketch showing a 1/17.8-scale model of the XFG-1 glider in the wire rig used for the longitudinal trim tests.
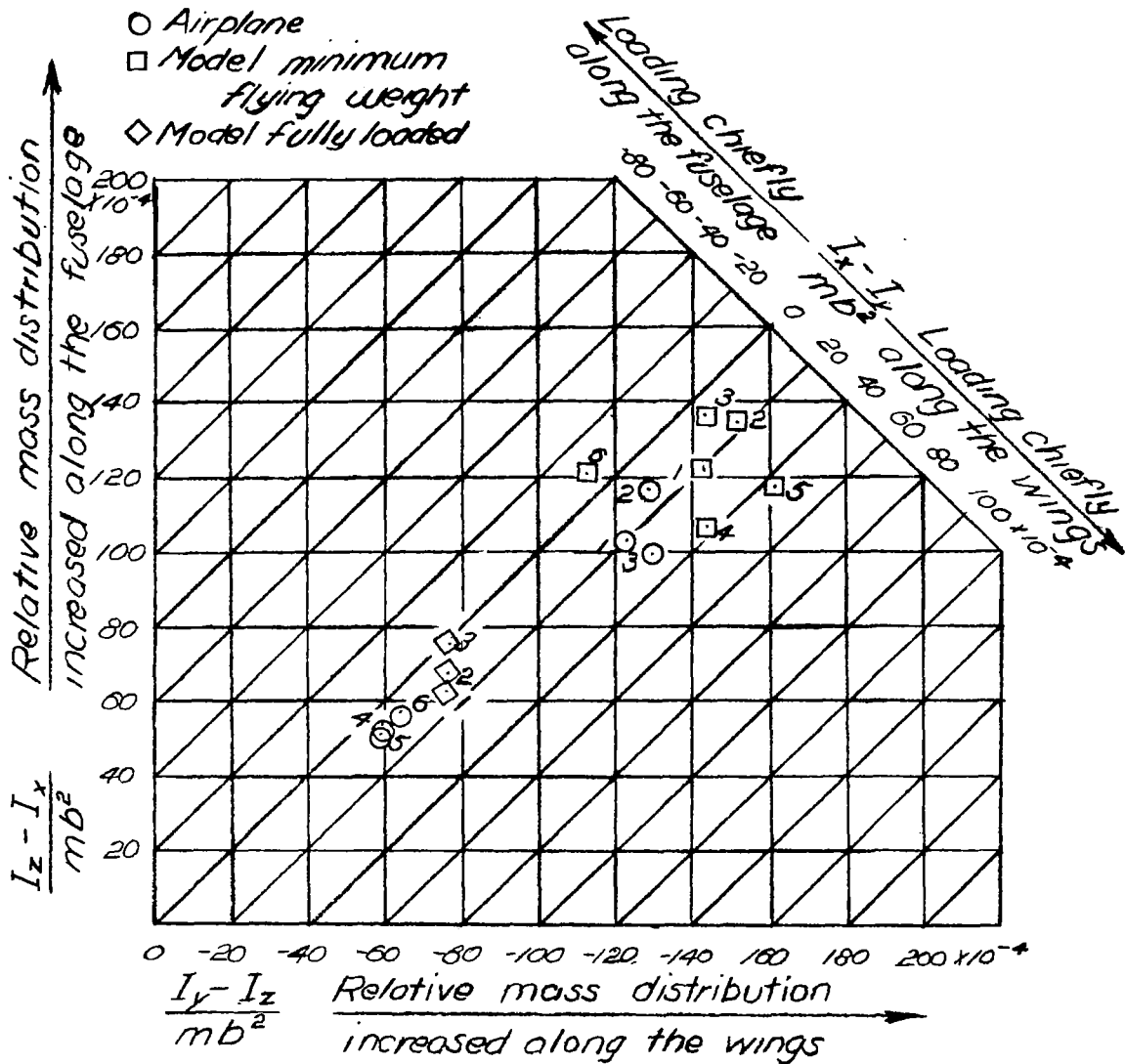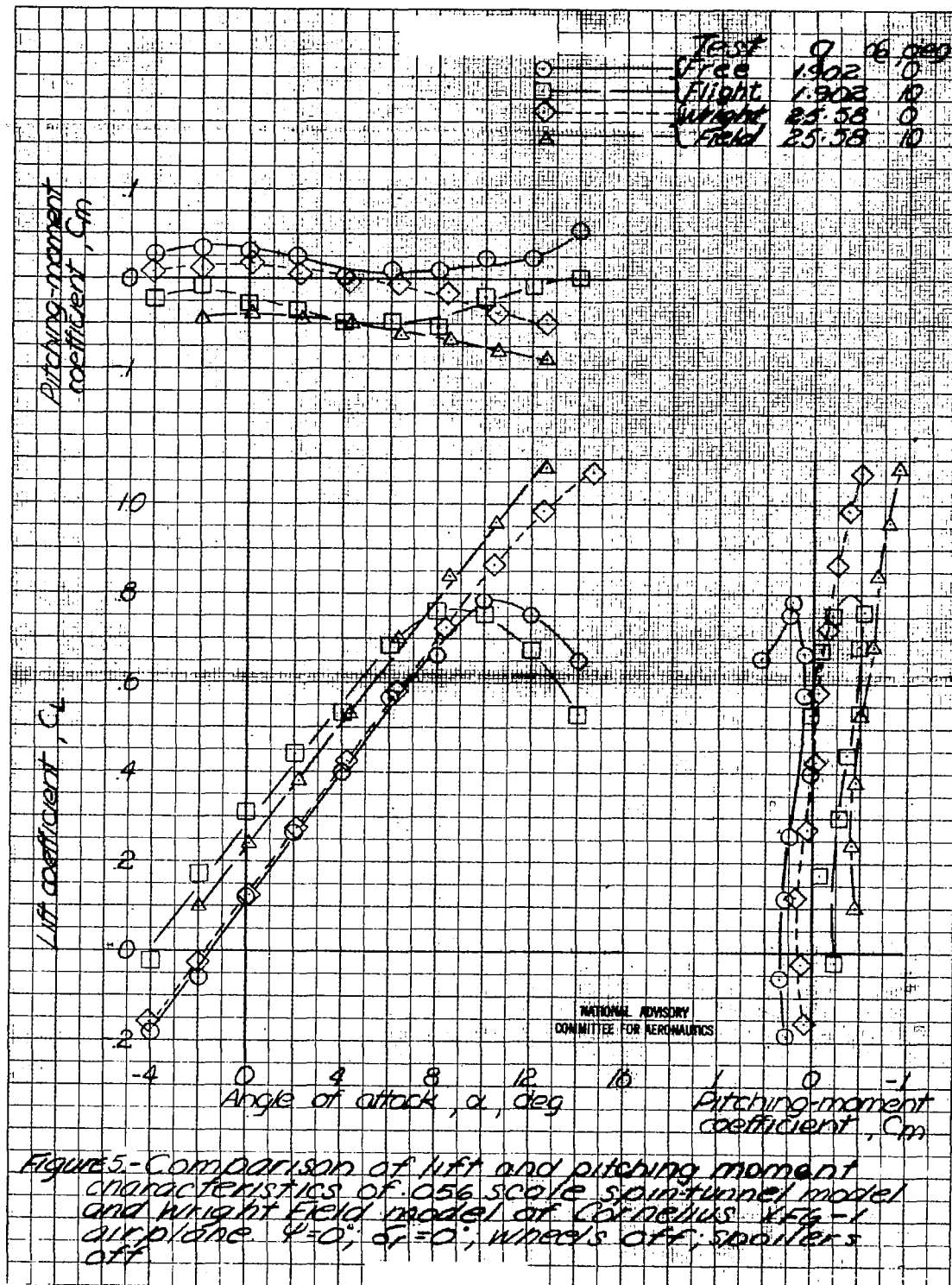
Figure 4. Mass parameters for loadings possible on the XFG-1 glider and for loadings tested on the model. (Points are for loadings listed in table III and IV.)

Figure 5.- Comparison of lift and pitching moment characteristics of .056 scale spin-tunnel model and Wright Field model of Cornelius XFG-1 airplane. ψ=0°, δr=0°, wheels off, spoilers off